Response of Tree Canopy Species of Kings Park, Perth, Western Australia to the Severe Summer Wildfire of January 1989

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Abstract

Plant communities subjected to severe and repeated perturbations tend to show simplified structure. Kings Park, an area originally reported to contain a eucalypt-sheoak (*Eucalyptus-Allocasuarina*) forest, has been sequentially reduced to a mixed woodland of sheoaks and banksia (*Banksia*), and more recently to a woodland dominated by sheoaks. Of the trees surveyed in the natural bushland section of Kings Park following the severe January 4, 1989 wildfire, only 37% were showing epicormic resprouts after 3 months. By September 1989 a total of 61% displayed either epicormic stem resprouts or basal resprouts and by May of 1990, following further resprouting, but also some later deaths, the total tree survival was 68% of the original tree population. Of this 68%, however, only 16% retained canopy resprouts after one year; the remainder essentially being reduced to the level of the shrub layer. At the level of species, the sheoak, *Allocasuarina fraseriana*, showed slightly better survival compared to the banksias, *B. attenuata*, *B. menziesii* and *B. grandis*, which, in turn, were better than any remnant eucalypts. Surviving trees tended to be trees of smaller than average diameter or height. Future summer fires are expected to further reduce the remaining tree canopy, thus further reducing the structural diversity of the native regions of the Park.

Introduction

The natural bushland areas of Kings Park formerly contained a open forest variously dominated by *Eucalyptus gomphocephala* DC. (tuart), *E. calophylla* Lindley (marri) and *E. marginata* Donn ex Sm. (jarrah). Over the past century this dominance by eucalypts has gradually given way to a low woodland consisting of *Allocasuarina fraseriana* (Miq.) L. Johnson (sheoak), *Banksia attenuata* R.Br. (slender banksia) and *B. menziesii* R.Br. (firewood banksia) (Beard 1967, Bennett 1988). The degradation appears correlated, in part, with frequent summer wildfires. In previous papers, it has been reported that this conversion to an open woodland of banksia and sheoak was due to the greater tolerance to fire (Main & Serventy 1956, Baird 1977) or the greater ability to compete for moisture (Beard 1967) of the sheoaks and banksias compared to the eucalypts, although no direct evidence was presented. Paradoxically, these authors also report that the banksias suffer the effects of fires less due to thick, hard bark compared to the sheoaks with their reported thin and rough bark, yet both species have successfully dominated the woodlands for at least the last thirty years when fires have been more frequent (Wycherley 1984).

On January 4, 1989, a very severe wildfire swept the central and southern regions of the Park (Fig 1), completely consuming the understorey and burning most of the canopy leaves and small branches. When resprouting from epicormic buds began to show following the fire, it appeared that many more trees failed to survive the fire than was expected from previous experience in the Park (Beard 1967, Baird 1977). In March, a section of burned woodland was surveyed and mapped to assess the impact of the fire on the survival of trees in the Park. Subsequent re-surveys in September 1989 and May 1990 documented further changes to the original canopy structure of this region. The report presented here compares differences between species, diameter and height of the trees over these three surveys.

* Wenona J. Ridley was tragically killed in an automobile accident between the time the original manuscript was prepared and its subsequent publication. The co-authors wish to express their deep sorrow for the loss of this young scientist early in her career.

Methods

A belt transect of 41 quadrats of 10 m X 10 m was established between Winthrop Avenue and May Drive (Fig 1). In each permanently marked quadrat all stems greater than 4 cm were mapped, measured for diameter at breast height over bark and estimated for tree height. Stems were identified to species and in the case of *Allocasuarina fraseriana*, female trees with 'cones' were noted separately from the male and non-reproductive trees. Trees showing resprouting during the March sampling period were recorded as alive; all others were recorded as dead. During the winter, it was apparent that some of the trees, originally recorded as dead, were producing basal resprouts. Consequently, in September all trees were re-assessed for survival and the form of resprouting (stem, basal or both) was noted.

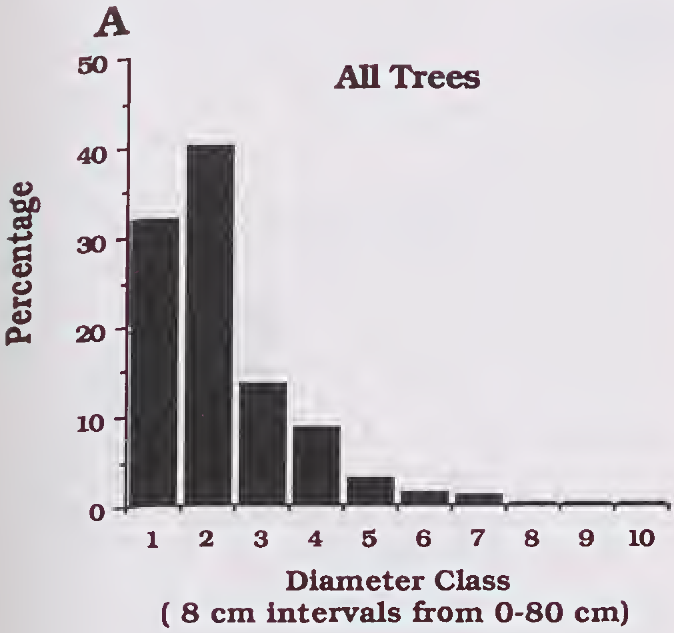
During the dry summer period, it was further noted that some trees that had initially resprouted had subsequently died, but there were additional trees, formerly assessed as dead but now showing basal resprouting. In May 1990, a third assessment of each tree provided categories of original fire deaths, deaths following some resprouting, survival as stem resprouters and survival as basal resprouts. All stems greater than 4.0 cm diameter at breast height (DBH) and over 2 m in height measured in March 1989 were assumed to constitute the original tree canopy population. The original population structure was assessed using size and height classes (8 cm and 1 m intervals, respectively). Analysis of Variance with Fisher's Least


Kings Park, Perth, Western Australia
Forrest Drive
Lovekin Drive
Arthur Fairall Playground
May Drive
Permanent Transect Line
Poole Avenue

Significant Difference (LSD) was used to determine the statistical significance of the matrices of taxa classified initially by response category and subdivided by height and diameter.

Results

The tree population sampled in Kings Park in March 1989, indicated that the sheoak, *Allocasuarina fraseriana*, numbered more than 55% of the stems occurring in the sampling transect (Table 1). The three members of the genus *Banksia* made up 38% of the stems with *B. attenuata* contributing 30% of this total. The eucalypts in the transect at the present time numbered only 3% of the tree stem total.



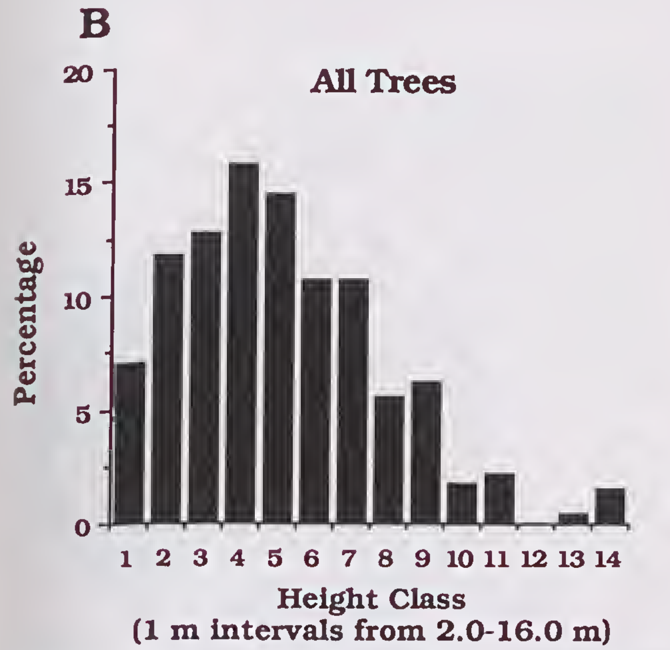


Figure 2. **A** Diameter class frequencies for diameter at breast height (classes of 8 cm beginning at 0 cm) and **B** height class frequencies (classes of 1 m beginning at 2.0 m) for the stem population in the Kings Park study transect of March 1989.

Table 1

Stem densities of trees in the Kings Park study transect in March 1989 (41 quadrats of 10 x 10 m)

Tree Taxa	Stems in transect	Stems per ha.	Relative Density %
A. fraseriana—Female	68	166	14.4
A. fraseriana—Male & Unknown Sex	195	476	41.3
Allocasuarina fraseriana— All stems	263	641	55.7
Banksia attenuata	140	341	29.7
B. grandis	7	17	1.5
B. menziesii	30	73	6.4
Eucalyptus gomphocephala	5	12	1.1
E. marginata	9	22	1.9
All other tree species	18	44	3.8
All trees	472	1,151	100.0

The patterns of diameter classes of the stems followed the typical negative exponential curve of frequency (Fig 2). Mean diameter for all trees was 14.0±0.5 cm. The somewhat reduced population of the first diameter (0-8 cm) class was caused by the limitation of 4 cm for the classification of trees for inclusion in the sample. The frequency of one metre height classes revealed a more poisson-like curve with a mean height of 6.2±0.1 m. Under the height and density system of Specht (1970), the vegetation prior to the fire would have been classified as a "low, open woodland".

The initial post-fire survey revealed that only 37% of the stems had resprouted in the three-month interval since the fire (Table 2). In the subsequent 6 months to September the total had risen to 61%, finally reaching a total stem survival record of 68% in May 1990. Although the initial record indicated that there was little difference between the survival of sheoaks and the banksias, the final record indicated that only 51% of the original banksia stems had resprouted by May 1990 compared to 82% for *Allocasuarina*. The remaining species, which included the eucalypts, fared even more poorly with only a 41% survival value 16 months following the wildfire. As with the she-oaks, 30-40% of the original stand of this group was recorded as dead at the first sampling, but subsequently produced resprouts.

The May 1990 assessment revealed that of the 33% of stems dead in the survey, most (29%) were killed directly by the fire; the remainder subsequently dying after having initally resprouted (Fig 3). About half (51%) of the original canopy population was reduced to basal sprouting individuals, with the remaining 16% as stem-resprouts. Compared to the partition for all stems, the better overall survival in *Allocasuarina fraseriana* was attributable to a greater ability to resprout from the base.

The division of sexes in *Allocasuarina* appeared to indicate that a greater proportion of females were killed by fire compared to the male and unreproductive category.

Table 2

Survivorship as judged by resprouting in the survey trees of Kings Park following the fire of 4 January 1989

Taxa	March 1989	September 1989	May 1990
All Trees	37%	61%	68%
Allocasuarina fraseriana	41%	77%	82%
All banksias	37%	41%	51%
All other species	6%	39%	41%

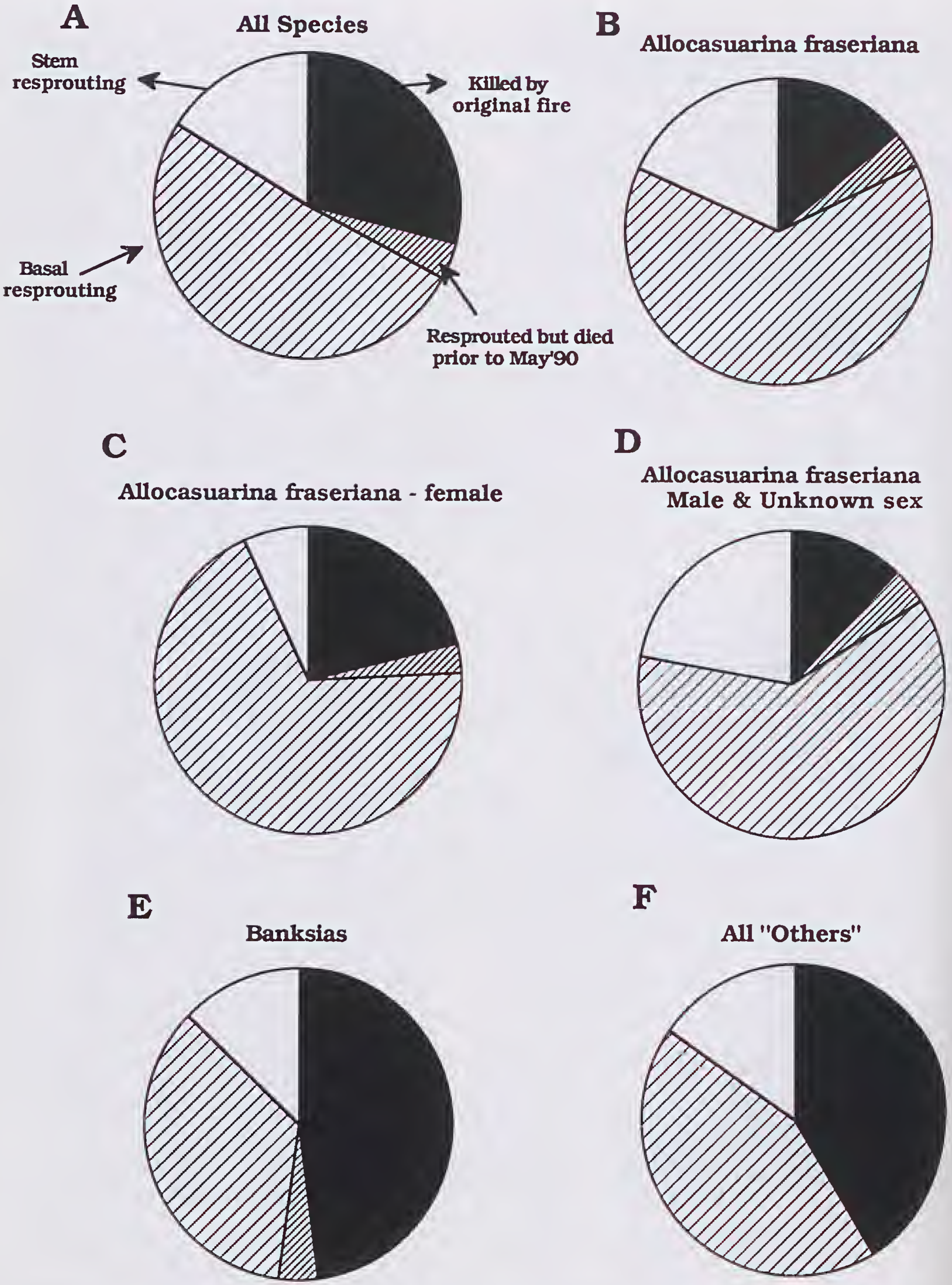


Figure 3. Proportions of stems of A All Species, *Allocasuarina fraseriana* (B all together and C D separated by sex), E the Banksias and F All "Other" species in the following categories: 1) Killed by the original fire; 2) Resprouting individuals which died prior to May 1990; 3) Stem resprouting individuals; and 4) Individuals with only basal resprouts.

However, this may be a spurious result since this latter category might be expected to contain stems which were genetically female, but did not carry fruit. The impact of the fire was generally greater on the banksias and the eucalypts with nearly half of their original populations of stems failing to resprout following the fire.

The analysis of variance revealed that the stems surviving the fire as basal resprouts only tended to be the smaller trees, both in diameter and height (Table 3). Also, the trees which initially resprouted but subsequently died were generally larger than those trees in the other categories. These trends were similar in all groups of taxa.

Discussion

The summer fire of January 1989 had a much more severe impact on the tree vegetation of Kings Park than had been observed following previous summer fires. Beard (1967) wrote "Both banksia and casuarina are hardy to fire and well withstand severe crown fires which destroy not only their leaves but the smaller branches as well." Baird (1977) was also impressed with the ability of the vegetation of Kings Park to survive fires, indicating that "none of the trees is fire-sensitive, all are capable of sprouting from epicormic buds although some suffer more damage than others." She also indicated that although none of the tree species were killed by fire, too frequent fires had a tendency to reduce certain species and that severe fires did kill the smaller saplings. Given these comments, the observed survival rates of only two out of every three trees following the latest severe fire, is clearly most unexpected.

The present study has unequivocally documented that the latest fire has had a drastic effect on the larger trees regardless of species. Under conditions of severe crown scorching it appears to be the smaller trees which have retained their ability to resprout and especially from basal epicormic buds. This is also somewhat unexpected since larger trees are presumed to have a greater underground store of living tissue, sources of dormant buds, and the water and nutrient reserve to nurture regeneration. There was no indication, however, that sheoaks suffer any more than banksias during severe fires, as previously suggested (Main & Serventy 1957, Beard 1965, Baird 1977). In fact, sheoaks were the most tolerant of species, being reduced by only one-fifth, although all species were drastically affected.

The emergent eucalypt component of the tree canopy has been greatly altered by this severe fire. Another such fire could be expected to kill many of the remaining canopy trees leading to the resulting vegetation being more properly characterized as a shrubland with occasional emergent trees.

Richer and Serventy (1991) argue that the regeneration of eucalypts in Kings Park following fires of the 1930's was limited due to competition for summer moisture with the undergrowth of banksias and sheoaks. Seedlings of the banksias and sheoaks will also suffer in competition with the established resprouting shrubs and remaining trees, further restricting the number of trees in the region.

Hazard-reduction burning in the 1950s and 1960s accelerated the conversion of the vegetation from a eucalypt-dominated to a sheoak-dominated woodland in this area of Kings Park (Main and Serventy 1957, Beard 1967). The 1989 severe wildfire appears to have accelerated this process. Of interest, however, is that the direction of this successional change is in direct contrast to that proposed for *Eucalyptus/Casuarina* associations in eastern Australia based on paleogeographical evidence from Lake George (Singh and Geissler 1985). However, the Casuarinas referred to from the pre-historical Lake George habitat would be more like *Casuarina obesa* and not of the fire-tolerant *Allocasuarina fraseriana*-type.

The permanent transect of mapped trees established in this study will allow the documentation of further changes in the tree population structure in Kings Park in coming years. For example, seedling regeneration is being followed and is to be assessed as part of a separate study of sub-canopy level responses to the January 1989 fire. Maintenance and protection of Kings Park as an urban bushland is an important virtue for city residents and the majority of park users want the part left "undisturbed" (Johnson *et al.* 1974). Unfortunately, given the continued expectation of further vandal-lit fires in the park, it is more likely that tree numbers will continue to decline in this inner city bushland.

Table 3

Mean diameters and heights (±se) in May 1990 for response categories of trees in the Kings Park tree survey. Values within a category with different superscript letters are different at $p<0.05$ by Fisher's LSD.

Taxa	RESPONSE CATEGORY Killed by Fire	Resprouted but died	Stem Resprouters	Basal Resprouters
DIAMETER (cm)				
All Stems	15.9 ± 1.1^{b}	24.9 ± 3.6^{a}	17.5 ± 1.0^{b}	11.0 ± 0.5^{c}
Sheoaks—all	21.3 ± 2.5^{b}	30.2 ± 4.8^{a}	17.8 ± 1.4^{b}	11.2 ± 0.6^{c}
Sheoaks—Female	27.8 ± 4.5^{b}	47.5 ± 2.5^{a}	23.7 ± 5.6^{b}	13.2 ± 1.4^{c}
Sheoaks—M.& U.	17.4 ± 2.8^{b}	26.7 ± 5.6^{a}	17.3 ± 1.4^{b}	10.5 ± 0.7^{c}
Banksias—all	13.7 ± 1.1^{a}	16.4 ± 2.0^{a}	16.4 ± 1.1^{a}	9.8 ± 0.7^{b}
All others	15.6 ± 3.5^{a}	—	10.5 ± 3.1^{a}	17.3 ± 5.1^{a}
HEIGHT (m)				
All Stems	6.4 ± 0.3^{b}	7.9 ± 0.7^{a}	7.5 ± 0.3^{a}	5.5 ± 0.2^{c}
Sheoaks—all	7.8 ± 0.6^{b}	8.8 ± 0.8^{a}	7.7 ± 0.4^{a}	5.6 ± 0.2^{c}
Sheoaks—Female	9.4 ± 1.0^{a}	12.0 ± 0.1^{a}	7.6 ± 0.9^{a}	5.5 ± 0.3^{b}
Sheoaks—M.& U.	6.8 ± 0.7^{a}	8.4 ± 0.9^{a}	7.6 ± 0.4^{a}	5.6 ± 0.2^{b}
Banksias—all	5.8 ± 0.3^{b}	6.1 ± 0.7^{ab}	7.0 ± 0.5^{a}	4.8 ± 0.2^{c}
All others	6.0 ± 0.6^{a}	—	6.0 ± 2.0^{a}	8.4 ± 1.0^{a}

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